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BIOLOGICAL ASSESSMENT OF THE KLAMATH PROJECT'S CONTINUING OPERATIONS ON SOUTHERN OREGON/NORTHERN CALIFORNIA ESU COHO SALMON AND CRITICAL HABITAT FOR SOUTHERN OREGON/NORTHERN CALIFORNIA ESU COHO SALMON

U.S. Bureau of Reclamation
Mid-Pacific Region
Klamath Area Office
Klamath Falls, Oregon

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1.0 INTRODUCTION

The Bureau of Reclamation (Reclamation) is the responsible Federal agency for operation of the Klamath Project (Project). The operation of the Project has been the subject of numerous previous consultations with the U.S. Fish and Wildlife Service (Service) under Section 7 of the Endangered Species Act. Severe drought conditions in 1992 and 1994 and resultant associated shortages in project water supplies and the 1997 listing of the southern Oregon/northern California (SONCC) coho salmon, *Oncorhynchus kisutch,* as threatened in the Klamath River highlighted the need for review of Reclamation's operations. This biological assessment (BA) describes the effects to federally listed species (i.e., coho salmon) and critical habitat from on-going operation of the project based on historic operations as further described in this BA. Reclamation is developing a long-term operations plan. The biological opinion (BO) resulting from this BA will be used to develop alternatives for the long-term operations plan EIS. Reclamation is preparing this EIS. The implementation of a preferred alternative from the long-term operations plan (presently under development) would be the subject of future ESA consultation.

This BA addresses the needs of anadromous fish with emphasis on SONCC coho salmon. It was developed using the best available scientific and commercial information on anadromous fish needs in the Klamath River.

Coho salmon were listed as threatened on June 6, 1997. The National Marine Fisheries Service (NMFS) has published a final rule designating critical habitat for SONCC coho salmon. Designated critical habitat for SONCC coho salmon encompasses accessible reaches of all rivers (including estuarine areas and tributaries) between the Mattole River in California and the Elk River in Oregon (May 5, 1999, 64 FR 24049). Critical habitat includes all waterways, substrate, and adjacent riparian zones below longstanding, naturally impassable barriers. The areas upstream from IGD were not proposed critical habitat because areas downstream were considered sufficient for the conservation of the species (NMFS 1997).

In this Biological Assessment, Reclamation has not analyzed whether the proposed operation of the Klamath Project is consistent with its trust responsibility to the Klamath Tribes. This is so because there are several important scientific reports and analyses that are currently not available to Reclamation concerning the endangered suckers, their habitat and water quality as it relates to appropriate lake levels that may be necessary for Reclamation to determine its obligation to operate the Klamath Project consistent with its trust responsibility to the Klamath Tribes. When this additional information becomes available, Reclamation intends to consider it in the development of its Klamath Project operations plans.

2.0 PROJECT DESCRIPTION

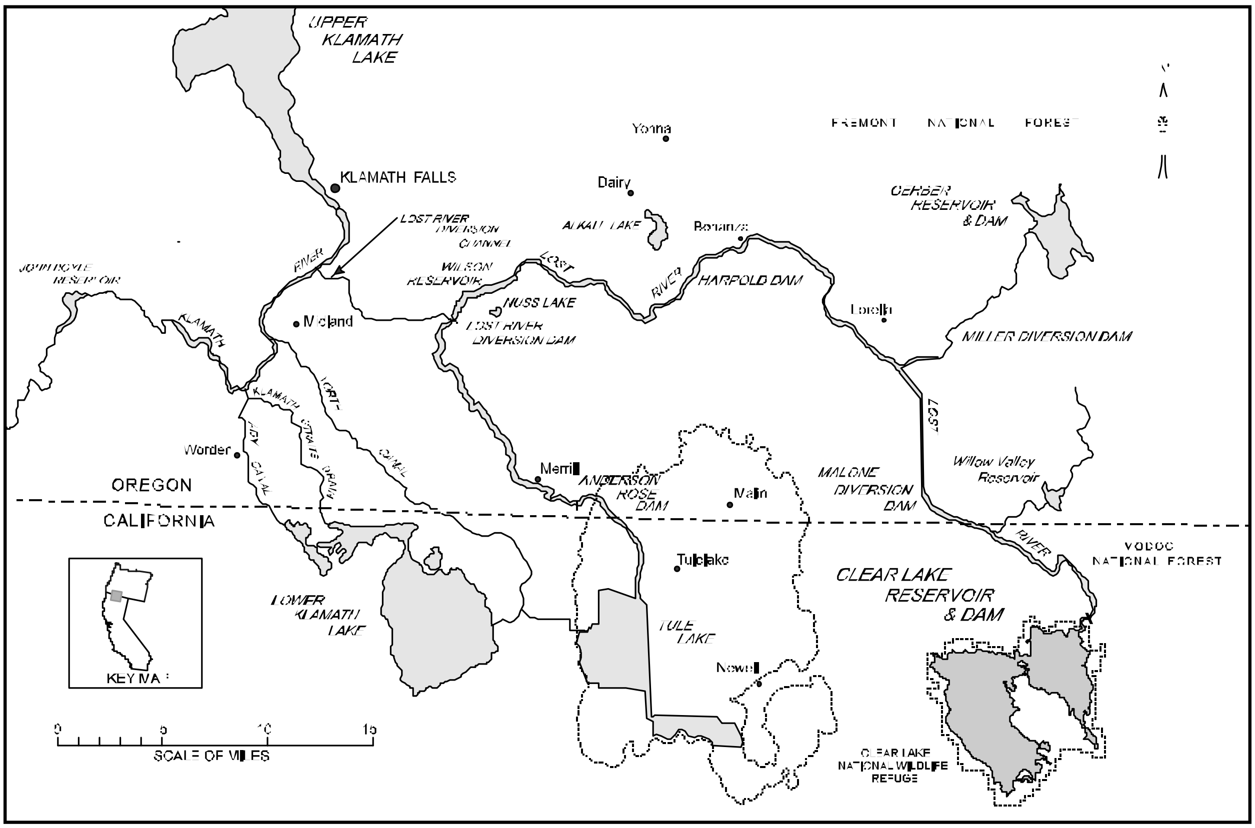
2.1 <u>General Operations</u>

The Klamath Project irrigates approximately 220,000 acres in three counties in south-central Oregon and northeastern California. The location of the Klamath Project is shown on Figure 1.

The Klamath Project delivers water primarily from Upper Klamath Lake in the headwaters of the Klamath River Basin and Gerber and Clear Lake Reservoirs in the Lost River watershed. A detailed description of project operations is presented in the 1992 Biological Assessment for Long-Term Operations of the Klamath Project (Reclamation 1992) and the report describing historic project operation (Reclamation 2000).

Figure 1.Klamath Project–location map

Various responsibilities and obligations affect project operations, including:



1) Project construction was authorized by the Secretary of the Interior on May 15, 1905, in accordance with the Reclamation Act. The Act of February 9, 1905 provides; *"The Secretary of the Interior is hereby authorized in carrying out any irrigation project that may be undertaken by him under the terms and conditions of the national reclamation act and which may involve the changing of the levels of Lower or Little Klamath Lake, Tule or Rhett Lake, and Goose Lake, or any river or other body of water connected therewith, in the States of Oregon and California, to raise or lower the level of said lakes as may be necessary..."*

2) Klamath River Compact of 1957 entered into between the states of Oregon and California and approved by the U.S. Congress which established goals and objectives for the development and management of water resources of the Klamath River Basin.

3) FERC license, Project No. 2082, establishes terms and conditions for operation of the Eastside and Westside Powerplants at Link River Dam, J.C. Boyle, Copco No. 1 and No. 2, and Iron Gate hydroelectric projects and Keno Dam. This license sets certain minimum flows at IGD (Table 1). Minimum flows, however, are subject to water availability and senior water rights. Pursuant to a 1956 contract with Reclamation, PacifiCorp operates Link River Dam and its appurtenant power generation facilities. Reclamation and PacifiCorp entered into a Letter Agreement on June 5, 1997, to clarify for FERC that PacifiCorp was operating Link River Dam pursuant to Reclamation authority under the 1956 contract, because the 1997 Klamath Project operations plan required Klamath River flows that were both greater and less than those included in PacifiCorp's FERC license. The Agreement has been extended each year to include that year's operation.

Table 1. FERC minimum daily average flows at Iron Gate Dam.

Month	Flow (cfs)	Month	Flow (cfs)	Month	Flow (cfs)
April	1,300	August	1,000	December	1,300
May	1,000	September	1,300	January	1,300
June	710	October	1,300	February	1,300
July	710	November	1,300	March	1,300

4) Endangered Species Act - Project operations affect four threatened and endangered species including the Lost River and shortnose sucker, southern Oregon/northern California coho salmon and bald eagle. In 1992, 1994, and 1996, the U.S. Fish and Wildlife Service (Service) issued biological opinions (BO) on the effects of the Project on the endangered suckers and bald eagles. The Service provided "reasonable and prudent alternatives" (RPAs) regarding water elevations in project reservoirs that would allow Project operation to continue without jeopardy to the listed species.

5) The United States has a trust responsibility to protect tribal trust resources. In general, the trust responsibility requires the United States to protect tribal fishing, gathering, hunting, and water rights, which are held in trust for the benefit of the tribes. Reclamation is obligated to ensure that Project operations not interfere with the tribes' senior water rights. With respect to the tribes' fishing rights, Reclamation must, pursuant to its trust responsibility and consistent with its other legal obligations, prevent activities under its control that would adversely affect those rights, even though those activities take place off reservation. Fishery and other resources in the Klamath River and Upper Klamath Lake provide religious, cultural, subsistence, and commercial support values for the Klamath Basin Indian tribes. The Klamath Basin Indian tribes include the Klamath, Hoopa Valley, Karuk, and Yurok Tribes.

6) Refuge Water Supplies - Four national wildlife refuges lie adjacent to or within Project boundaries--Lower Klamath, Tule Lake, Clear Lake, and Upper Klamath Lake National Wildlife Refuges. The refuges either receive water from, or are associated with Project facilities.

2.2 KPOPSIM Model

Reclamation developed a water accounting spreadsheet model (KPOPSIM) that simulates project operations to help evaluate the impacts of varying water deliveries to overall project operations. It defines the available water supply including monthly runoff into Upper Klamath Lake and water demands at various locations. In addition, estimates of flow accretions downstream of project facilities have been developed. Criteria for operations, including administrative, legislative, legal, or contractual requirements, are incorporated into the model. Using the model, monthly estimates of water deliveries to the various users, reservoir releases, instream flows at specific locations, reservoir storage, Upper Klamath Lake levels and pumping quantities can be determined. The model allows alternative operation scenarios to be analyzed with key operations indicators used to determine the ability of the project to meet various water users' demands. Detailed description of the model components, inputs, and assumptions are found in CH2M Hill (1997). The model has been presented for preliminary review and comment, and will undergo further review and refinement. The model is based on the last 38 years (1961 through 1998) of hydrological record, and uses expected comparable preceding year types to predict outcomes.

2.3 Project History

The Klamath Project was authorized in accordance with the Reclamation Act (43 U.S.C. Sec. 372 et seq, Act of June 17, 1902, 32 Stat. 388) in May 1905 (Reclamation 1992 and 2000).

2.4 Contracts and Water Rights

Contracts and water rights are described in the 1992 BA (Reclamation 1992) and report on historic operations (Reclamation 2000). See also 1995 and 1997 Regional Solicitor's memorandums.

2.5 Facilities

2.5.1 Klamath Irrigation Project

Project facilities are described in Reclamation's 1992 BA (Reclamation 1992) and report on historic operations (Reclamation 2000).

2.5.2 PacifiCorp's Klamath Hydrofacilities

Project facilities are described in Reclamation's 1996 BA (Reclamation 1996) and report on historic operations (Reclamation 2000)..

3.0 ENDANGERED SPECIES ACT

3.1 Endangered Species Consultation History

In 1995, Reclamation conferred with the NMFS on the effects of the 1995 Klamath Project Operations Plan on Klamath Mountains Province steelhead (*O. mykiss*) (proposed listing). On April 7, 1995, NMFS sent Reclamation a letter of concurrence stating that the proposed operations for 1995 were not likely to jeopardize Klamath Mountains Province steelhead. This concurrence was based on: 1) the expectation that 1995 Project operations would allow for the minimum flow schedule outlined in the IGD FERC license to be met; and 2) the understanding that proposed operation of the Project included development and implementation of a long-term operating plan for the Project that would fully consider the needs of anadromous fish below IGD. Subsequently, Reclamation altered the time line and scope of the long-term operations plan.

Reclamation coordinated with NMFS regarding 1996 Project operations, including the downstream flows that were implemented that year. A technical review was provided of Reclamation's memoranda supporting the 1996 Klamath Project Operations Advisory. The coordination also occurred in regard to the 1997 Annual Operations Plan.

Reclamation coordinated with NMFS regarding the development of the 1998 Project operations and its consequences to threatened coho salmon, the proposed Klamath Mountain Province steelhead and candidate species chinook salmon (*O. tshawytscha*). On February 11, 1998, Reclamation requested formal consultation on coho salmon pursuant to the ESA for the 1998 Project operations. On April 1, 1998, Reclamation provided NMFS a BA on coho salmon pursuant to ESA for the 1998 Project operations (Reclamation 1998). The 1998 Project operations met or exceeded the minimum flow schedule as outlined in the IGD FERC license, August and September excepted.

In March 1999, Reclamation submitted an Environmental Assessment (EA) on the 1999 Project operations to NMFS. The preferred alternative in the 1999 EA was virtually identical to the Project operations described in the 1998 BA. NMFS agreed that for the purposes of ESA Section 7 consultation, the 1998 BA adequately described proposed 1999 Project operation and potential impact to coho salmon. NMFS delivered a draft BO to Reclamation regarding the 1999 Project operations in July 1999. Reclamation provided a written supplement to the EA/proposed action (i.e., flows higher than the 1998 Plan minimums). NMFS issued a BO on the amended proposed action and concluded that the amended proposed action was not likely to jeopardize SONCC coho salmon.

In November 1999, Reclamation provided funding to and cooperated with Dr. Hardy of Utah State University (USU), U.S. Geological Survey (USGS), and the Service to examine incremental changes in flow and available total habitat (microhabitat plus macrohabitat). Reclamation anticipates that these analyses would then be used in Section 7 Consultations and for the EIS on the long-term multi-year Project operations plan.

On January 31, 2000, USU informed Reclamation that Dr. Hardy's instream flow report would not be completed until late 2000. However, Reclamation's ESA coverage on coho salmon expired April 1, 2000. Reclamation sent a letter, dated September 14, 2000 to NMFS requesting an updated species list. On September 25, 2000, NMFS provided Reclamation with a list of Federally listed species and critical habitat that may occur downstream of Iron Gate Dam on the Klamath River.

4.0 PROPOSED ACTION

Reclamation proposes to direct the operation of project facilities to supply water to project water users and refuges, while observing certain river flow criteria for the Klamath River. The river flows illustrated in Table 2 are the result of operation of the Project within the scope of this BA. Since 1995, Reclamation has operated the Klamath Project according to an annual operations plan. Each of these years were above average water year conditions. The most recent annual operations plan is dated April 26, 2000 and covers the period of April 1, 2000 through March 31, 2001. This water year was a below average water year. The annual operation plans have been developed to assist Reclamation in operating the Klamath Project consistent with its obligations and responsibilities, given varying annual hydrological conditions. Reclamation has described actual operation of the project in this BA using historic data regarding Klamath River flows from1961 through 1997. This period encompasses the time when existing project features/facilities have been in operation and it is the period of hydrological and project operation records incorporated into the water accounting spreadsheet model (KPOPSIM) for the Klamath Project.

Project operation has been influenced during this period by events and actions such as: (1) varying hydrological conditions in the watershed from year to year; (2) changes in the Klamath River watershed and lands adjacent to Upper Klamath Lake; (3) changes in agricultural cropping patterns; (4) changes in national wildlife refuge operations; (5) previous consultations under Section 7(a)(2) of the ESA; (6) increased scientific understanding of fish habitat needs has led to a better understanding of trust responsibilities for Klamath Basin Indian tribes, both upstream and downstream of the project; and (7) its obligations and responsibilities described in the July 25, 1995 and January 9, 1997 Regional Solicitor's memorandum.

4.1 <u>Water Year Type Description</u>

The 37 years of historic April through September net inflow data to Upper Klamath Lake (using 1996 bathymetric data) was used in the statistical analysis to determine the hydrologic year type indicators for the KPOPSIM water model. The first step was found to have a normal distribution.

All of the following work was conducted in Excel 97. Once this determination was made the arithmetic mean (average) was calculated and found to be 500,400 acre feet. Next the standard deviation (based on sample) was calculated and found to be 187,600 acre feet. This suggests that approximately 68% of the inflow years fall within the range of 500,400 +/- 187,600 acre feet. The average minus one standard deviation equaled approximately 312,000 acre feet. So between 500,000 acre feet and 312,000 acre feet is an area defined as below average inflow. Because there are significant operational spills for inflows above 500,000 acre feet, the upper end of the area defined by mean plus one standard deviation was not used and 500,000 acre feet was used as the above average indicator. For the boundary between critical and dry, the mean plus and minus one standard deviations were calculated and found to be lower than the lowest inflow on record. Since this couldn't be used, percentile rankings were developed for the full 37 years of inflow data and the third percentile was found to be 185,000 acre feet and was used for the dry indicator. Anything below the dry indicator would be classified as a critical year.

4.2 Project Operation Description

From 1961 through 1994, prior to the increased scientific understanding of fish habitat requirements, Project operation decisions for flows downstream of Iron Gate Dam were made in coordination with PacifiCorp with consideration for current inflow, projected runoff, and projected irrigation and refuge needs. Deference was given to PacifiCorp's FERC flow schedule requirements when sufficient water supply was available. However, review of historic flow data contained in Table 2 illustrates that the actual flows realized reflect an operation within hydrologic constraints and deliveries for agricultural and refuge uses, with a relatively minor influence of the FERC flow schedule. The data in Table 2 also illustrate the lack of storage capability within the Klamath Project.

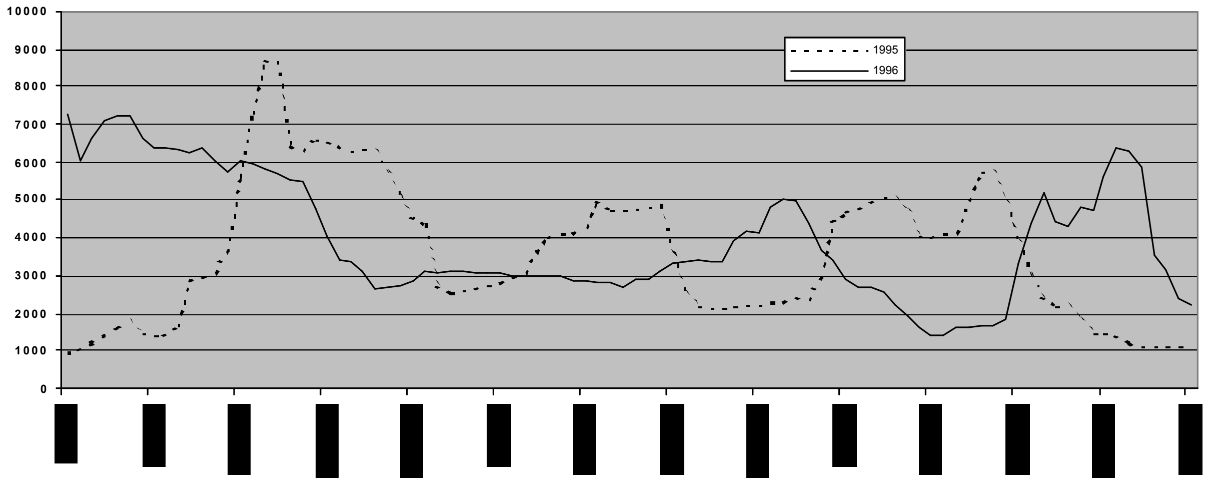
October - March

Irrigation and refuge water demands from October through March were relatively nominal, and the flow at Iron Gate was a function of balancing filling of Upper Klamath Lake against downstream flows. When flows exceeded the FERC minimum of 1300 cfs (note: because the FERC minimum is an instantaneous value, when operating to the minimum the average is generally 20 to 50 cfs above the minimum), it was a function of passing inflow to maintain flood control elevation in Upper Klamath Lake. The contrast between water year types is evident from the record during this period.

April - June

April through June is a transition period including the recession of snow pack runoff and the onset of summer irrigation demand. The timing of runoff is highly dependant on weather and snow pack conditions. Upper Klamath Lake is operated to fill in accordance to flood control criteria and in consideration of forecasting of runoff from remaining snow pack. Inflow in excess of filling and diversion needs is released at Link River Dam. Link River releases and down stream accretions make up the flows at Iron Gate Dam. Typically there is a "lull" between late winter low elevation runoff and the onset of higher elevation snow melt. This has often resulted in a temporary reduction of flow at Iron Gate Dam. These fluctuations in flow are dependant on weather conditions that affect snow melt. Figure 2 illustrates these conditions. Reclamation will explore ways to minimize the depressed flows that occur during this period.

Figure 2. Klamath River Flows (CFS) Below Iron Gate Dam (1995-96)



July - September
Snow pack has generally melted prior to this period. Inflow to reservoirs is the result of springs, stream flow and occasional summer storms. During this period, the Project draws upon reservoir storage in addition to inflow to provide irrigation for crop production, refuge needs and flows to the Klamath River.

4.3 <u>Klamath River Flows Below Iron Gate Dam</u>

Table 2 contains historical data (1961 through 1997) for IGD flows based on USGS daily flow records for the period of operation encompassed by this BA. This table summarizes the historical daily minimum, maximum and average flows for the 17 time steps for each water year type (critical dry, dry, below average and above average). USGS data for historical flow at Iron Gate Dam is provided in daily cubic feet per second (cfs). Values for average monthly (or half-monthly) flow were developed for every time step in the period of record. These values were then split up by year type. Take the "Dry" year type and the "October" time step for an example. Five years in the period of record are designated as dry. The 5 average flow values for Octobers in dry year types can be considered together to calculate an overall average for dry Octobers. Among these 5 values is also a lowest and highest, and these are the maximum and minimum values that appear in the table.   This approach was used for every time step for every year type to create the tables.

Table 2. Historic Iron Gate Dam flows (1961 through 1997-- values in cfs).

	19 Above Average Years				11 Below Average Years			
Time Step	Maximum	Minimum	Average	St. Dev.	Maximum	Minimum	Average	St. Dev.
Oct	3353	1329	1912	586	2511	1308	1592	345
Nov	5254	1337	2547	1071	2986	1324	1999	621
Dec	6735	1387	2987	1213	6653	1435	2835	1507
Jan	9553	1127	3249	1785	9489	1334	3166	2337
Feb	9150	910	4143	2244	5656	1546	2532	1156
Mar 1-15	12447	1953	4864	2851	5017	1439	2501	1006
Mar 16-31	9219	2101	5268	2008	3682	1748	2391	591
Apr 1-15	9254	1781	4805	1906	3067	1455	2009	587
Apr 16-30	7205	1629	3860	1179	2493	1305	1701	426
May 1-15	5005	1730	3383	1088	2083	1010	1351	372
May 16-31	6247	1026	2761	1329	1714	1003	1188	228
Jun 1-15	4495	760	1764	1150	1480	728	912	230
Jun 16-30	2084	742	1031	365	1295	696	806	163
Jul 1-15	2194	705	870	327	940	709	758	69
Jul 16-31	1122	680	772	107	1023	682	784	94
Aug	1208	1011	1049	46	1094	701	995	104
Sep	2052	1035	1457	206	1428	725	1272	184

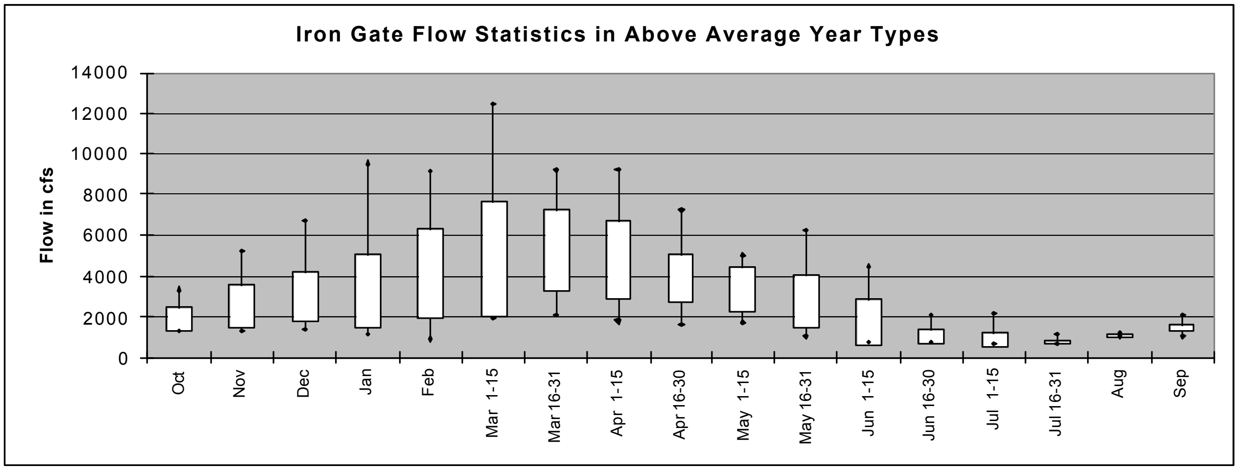
Table 2. Continued

	5 Dry Years				2 Critical Years			
Time Step	Maximum	Minimum	Average	St. Dev.	Maximum	Minimum	Average	St. Dev.
Oct	1382	852	1094	220	937	904	920	16
Nov	1390	873	1218	189	915	909	912	3
Dec	3903	889	2290	1305	944	914	929	15
Jan	4348	888	2588	1307	1191	1011	1101	90
Feb	2217	747	1554	505	730	525	627	103
Mar 1-15	2790	725	1683	817	712	501	607	106
Mar 16-31	2148	724	1464	545	572	521	547	26
Apr 1-15	1767	728	1183	381	843	569	706	137
Apr 16-30	1325	754	1039	241	636	574	605	31
May 1-15	1025	761	968	104	741	525	633	108
May 16-31	1039	924	996	41	714	501	608	106
Jun 1-15	931	712	782	77	706	476	591	115
Jun 16-30	735	612	700	45	702	536	619	83
Jul 1-15	739	547	669	76	572	429	501	71
Jul 16-31	742	542	678	75	575	427	501	74
Aug	1033	647	824	152	636	398	517	119
Sep	1048	749	953	112	906	538	722	184

Figures 3a, 3b, 3c, and 3d graph the data in Table 2. The graphs have boxes whose upper and lower bounds represent the average + 1 standard deviation and the average -1 standard deviation respectively, and lines running up and down from the boxes which represent the magnitude of the maximum and minimum values that went into the average and standard deviation.

<u>Above Average Year (See Figure 3a.)</u>
Above average years occurred in 19 of the 37 hydrologic years utilized for this assessment (51.3%). The minimum time step ranged from 680 cfs in the later part of July to 2,101 cfs in the later part of March. The average time step ranged from 772 cfs in the later part of July to 5,268 cfs in the later part of March.

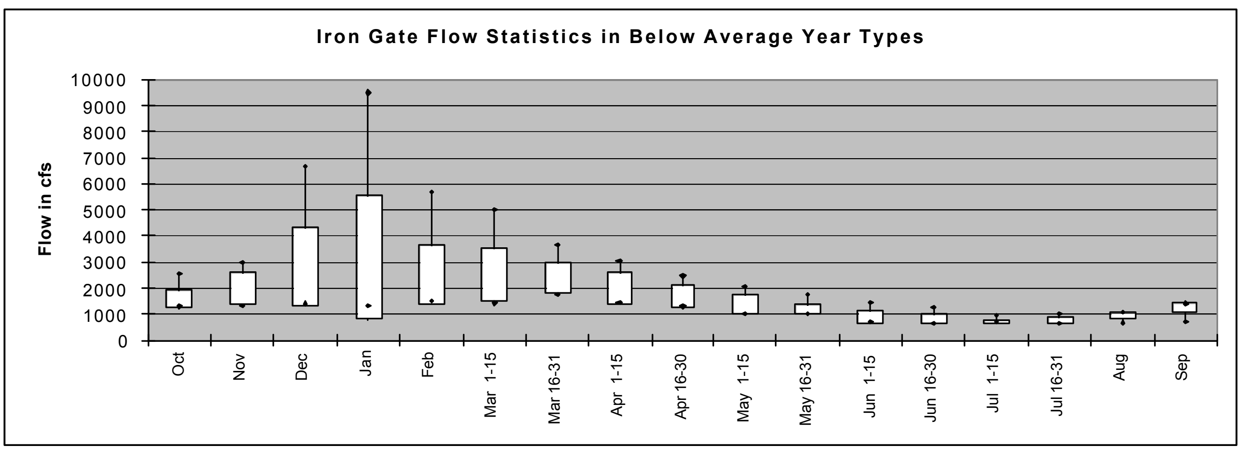
Figure 3a. Iron Gate Flow Statistics–Above Average Year Types



Below Average Year (See Figure 3b.)

Below average years occurred in 11 of the 37 hydrologic years utilized for this assessment (29.7%). The minimum time step ranged from 682 cfs in the later part of July to 1748 cfs in the later part of March. The average time step average ranged from 758 cfs in the later part of July to 3166 cfs in January.

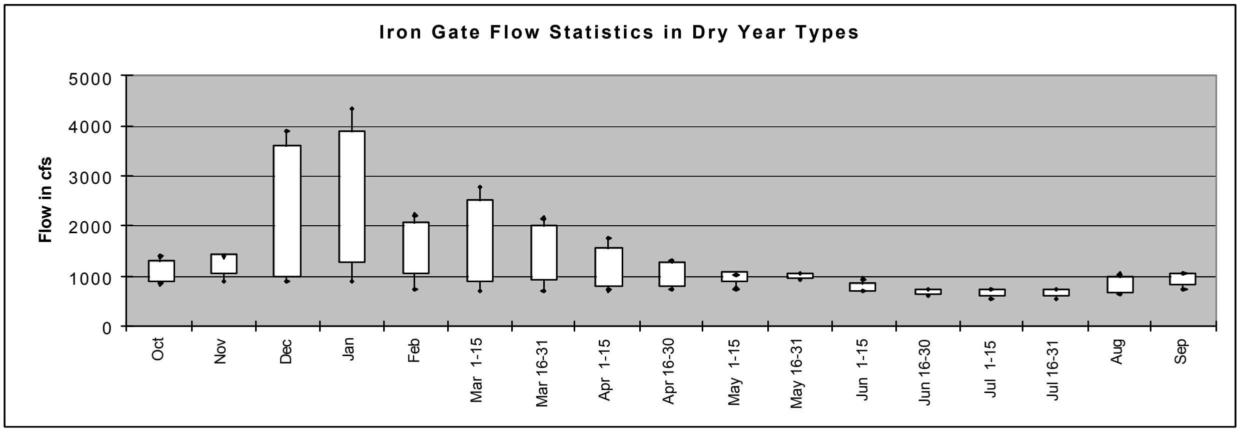
Figure 3b. Iron Gate Flow Statistics–Below Average Year Types



Dry Year (See Figure 3c.)

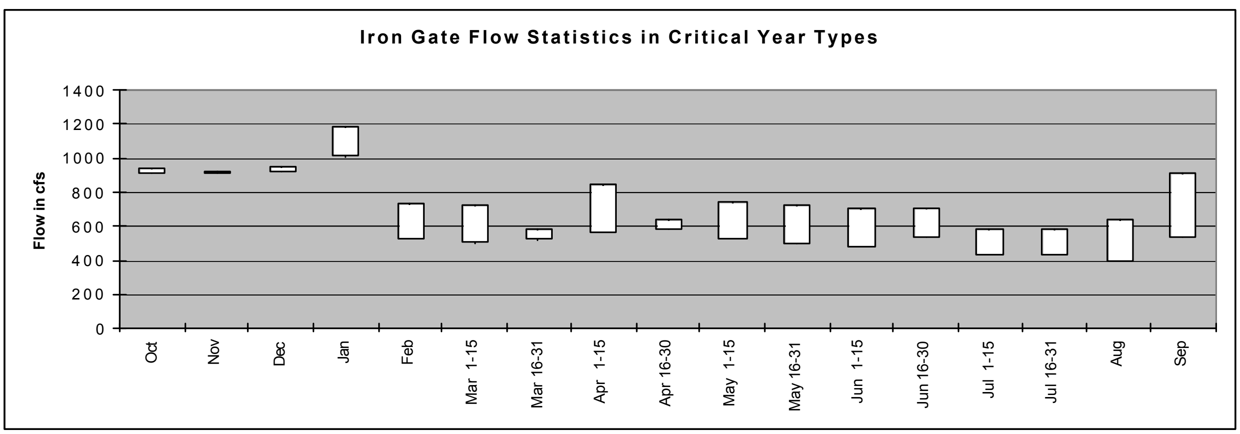
Dry years occurred in 5 of the 37 hydrologic years utilized for this assessment (13.5%). The minimum time step ranged from 542 cfs in the later part of July to 924 cfs in the later part of May. The average time step ranged from 669 cfs in the later part of July to 2588 cfs in January.

Figure 3c. Iron Gate Flow Statistics–Dry Year Types



Critical Year (See Figure 3d.)
Critical years occurred in 2 of the 37 hydrologic years utilized for this assessment (5.5%). The minimum time step ranged from 398 cfs in August to 1011 cfs in January. The average time step ranged from 501 cfs in July to 1101 cfs in January.

Figure 3d. Iron Gate Flow Statistics–Critical Year Types



Agricultural and Refuge Water Use

Water is diverted from Project facilities to provide for crop production and needs on National Wildlife Refuges located within the Project service area. Table 3 illustrates these uses for the portion of the area served from Upper Klamath Lake.

Table 3. Crop and Refuge Water Use from Upper Klamath Lake (1961 through 1999–values in thousands of acre feet)

	19 Above Average Years			11 Below Average Years		
Time Step	Maximum	Minimum	Average	Maximum	Minimum	Average
October	28.9	6.58	17.78	27.77	12.34	18.53
November	15.86	.49	6.78	14.25	2.28	6.81
December	17.28	.39	8.68	16.43	1.52	8.5
January	22.74	5.43	12.43	23.57	6.24	13.79
February	17.64	2.33	7.28	11.10	2.94	8.03
March	12.87	.3	4.69	10.68	1	6.07
April	52.85	5.49	21.14	52.85	21.92	36.17
May	76.70	28.95	55.15	81.83	50.55	65.49
June	103.54	45.33	81.72	102.05	73.11	86.17
July	105.38	75.33	91.35	104.55	75.37	93.25
August	87.20	47.71	74.63	88.58	36.08	71.50
September	61.45	34.63	48.09	60.95	40.15	48.76

Table 3. Continued

	5 Dry Years			2 Critical Years		
Time Step	Maximum	Minimum	Average	Maximum	Minimum	Average
October	29.13	8.83	20.50	31.17	14.62	22.90
November	16.52	1.5	6.15	9.51	5.57	7.54
December	17.09	6.15	11.99	20.33	15.26	17.80
January	20.67	9.33	13.72	19.70	11.14	15.42
February	12.12	2.23	7.27	12.60	7.35	9.98
March	17.99	1.75	10.15	16.30	11.07	13.69
April	67.32	27.11	41.53	63.63	57.64	60.64
May	58.73	37.60	50.47	90.12	51.50	70.81
June	91.75	70.99	81.70	87.66	78.67	83.17
July	99.81	87.40	95.28	103.77	58.25	81.01
August	83.48	76.26	79.37	90.84	64.91	77.88
September	66.07	49.63	58.56	33.46	32.15	32.81

4.4 PacifiCorp Hydrofacilities Operations

PacifiCorp operates its facilities to produce electrical power at the Westside and Eastside Plants at Link River Dam, Keno Dam, J. C. Boyle Dam, Copco No. 1 and Copco No. 2 Dams, and Iron Gate Dam in accordance with Reclamation's annual operations plan, FERC license requirements, and the applicable U.S. Fish and Wildlife Service B.O. for Upper Klamath Lake levels (T. Olson, PacifiCorp pers. comm. 1998).

Over the last 39 years, project operations pursuant to the contract between Reclamation and PacifiCorp have been influenced by the FERC license minimum flow schedule for IGD (FPC 1961). During below average and above average precipitation years, IGD releases usually exceeded the FERC minimums during the fall and winter while during dry years releases occasionally dropped below the minimums particularly during the summer months. In critically dry years (e.g., 1992 and 1994), releases were lower almost every month of the year.

4.5 Klamath River Anadromous Fish Action Items

The following action items are included in the proposed Federal action to assist in the recovery of the southern Oregon/northern California coho salmon.

4.5.1 Reclamation Responsibilities:

1) *Mainstem Klamath River Juvenile Emigration Monitoring* - Reclamation funded a cooperative program to monitor emigrating anadromous fish status downstream of IGD. Reclamation will assist with annual funding of the Big Bar monitoring site. This monitoring program has been conducted since 1989 by the Service, Coastal California Fish and Wildlife Office (CCFWO) and has been partially funded by the Klamath River Task Force (Task Force). Temporal abundance indices for various salmonid species will be developed and used in evaluating the effects of project operations. The objective of this project is to continue the monitoring of juvenile chinook salmon, coho salmon, and steelhead populations emigrating in the mainstem Klamath River. Information collected will be used to estimate annual abundance, natural and hatchery composition, peak emigration timing, size, health, and age class of juvenile salmonids. In addition, data are collected on other fish species including chum salmon, rainbow and brown trout, American shad, green sturgeon, river and Pacific lamprey.

2) *Water Supply Initiative* - In 1996, Reclamation's Klamath Basin Area Office (KBAO) entered into a partnership with the Oregon Water Resources Department (OWRD), the California Department of Water Resources (CDWR), and the Klamath River Compact Commission (KRCC) to explore options to increase water supplies in the Klamath River Basin. The need to improve supplies has resulted from increased demands for water for Endangered Species Act listings and Indian Trust resources, which have in turn reduced flexibility in providing water to agriculture and National wildlife refuges. The Klamath Tribes and certain Klamath Project irrigation interests requested in a letter of July 15, 1998, that the

Department of the Interior study a short list of water supply augmentation projects in the Klamath Basin which may be needed to bring water supply and demand into balance.

Solutions may include a number of actions that collectively could provide operations flexibility, i.e., new storage facilities (on stream or off stream), raising existing dams, agriculture demand management, water import/export opportunities, operational changes, groundwater pumping, reducing evaporation/seepage, and habitat restoration.

A draft report identifying potential options for increasing water supplies was released in October 1997. A revised draft was released in January 1998 with a final draft in July 1998. The report identifies which options appear most promising for additional study, based on information currently available. The following options are being actively investigated by KBAO at the present time. Additional efforts will be advanced as funding and resources become available.

Raise Upper Klamath Lake

Under a service agreement with KBAO, Reclamation's Technical Service Center (TSC) in Denver is conducting an appraisal level study on the desirability of raising the maximum operating water surface of Upper Klamath Lake by up to 2 feet to elevation 4145.3. Two alternatives are being considered: 1) construction of new dikes and sea walls and modification of existing dikes to contain the lake within its current boundaries, and 2) acquisition of lands inundated by raising the lake without structural construction or modification to contain it within current boundaries.

The draft Appraisal Study Report (July 2000) shows an estimated cost of $125 million and $129 million for options 1 and 2, respectively. Based on the initial findings, more detailed feasibility studies on raising the lake are recommended.

Groundwater Investigations

While knowledge of local groundwater conditions increases, a comprehensive study of the groundwater system in the Klamath Basin is needed. The ability of the resource to sustain existing uses and to accommodate additional development is not well known, and there is substantial uncertainty about the extent to which groundwater development will impact surface water resources throughout the basin. In FY 1998, OWRD and the USGS began a cooperative groundwater investigation of the basin. Objectives of the study are to develop a quantitative conceptual understanding of the system, construct numerical models that accurately simulate the system, describe the system through reports and presentations, and use hydrologic models to help determine optimal management alternatives. The study is scheduled for completion in FY 2005.

In FY 1999, KBAO entered into a cooperative agreement with OWRD to implement a groundwater development program in the Klamath and Lost River Basins in Oregon. The program is intended to assess the feasibility of obtaining supplemental water supplies for the Klamath Project. An existing well in the Shasta View Irrigation District (SVID) was pumped in the early spring of 1999 to test the underlying aquifer. Preliminary results of the test indicate good potential for high production wells in the area with low potential to interfere substantially with other wells.

KBAO has entered into a cooperative agreement with CDWR to help assess the potential for groundwater augmentation in the California portion of the Klamath and Lost River Basins. Under the agreement in FY 1999, CDWR located existing wells, correlating them with available well completion reports, took initial water level measurements where possible, identified data gaps, and compiled data obtained in digital format. Beginning in the fall of 1999 (FY 2000), CDWR is performing semiannual water level measurements on 35 of the wells over a 3-year period. The data collected will be compiled in digital format.

Raise Gerber Dam

The TSC recently completed a cursory review of existing information to determine the feasibility of raising the active storage capacity of Gerber Dam by 3 feet. The review indicates that raising the dam is a viable option for increasing water storage in the Klamath Basin, although additional studies are needed to support this determination. KBAO is developing a service agreement with the TSC to begin an appraisal study on raising the dam. This study is expected to be completed later in 2000.

Agency Lake Ranch

In 1998, Reclamation acquired the 7,123-acre Agency Lake Ranch on the west side of Agency Lake at the north end of Upper Klamath Lake. The ranch, a former pasture, is being used to increase supplies by approximately 10,000 acre-feet of water which would otherwise be spilled to the Klamath River during periods of high runoff. Existing dikes surrounding the ranch could be raised to capture 35,000 to 40,000 acre-feet of spill water. A management plan is currently being developed for the Ranch.

5.0 COHO SALMON GENERAL INFORMATION

5.1 Identification

Coho salmon, also known as silver salmon because of their brilliant silver coloration in the ocean phase, can be identified from other salmon by a few unique characteristics. Unlike steelhead, coho have 13 or more anal rays (Wydoski and Whitney 1979). Coho have distinctive small irregular black spots on their back and caudal fin much like chinook salmon. The difference in spotting between the two species is coho have spots only on the upper lobe of the fin while chinook have spots on both lobes (Wydoski and Whitney 1979). Coho can also be distinguished from chinook by the color of the gums around the base of the teeth. Coho have white gums, chinook black gums (Wydoski and Whitney 1979). Juvenile coho are identified by having long anterior rays on the anal fin (Wydoski and

Whitney 1979). The first three anal rays of the fin are much longer than the other rays giving the fin a sickle-shaped appearance.

In describing the species, Scott and Crossman (1973) include the following morphological characteristics of coho: vertebrae range from 61 - 69, lateral line is complete with 121 - 148 scales, pyloric caeca vary from 45 - 114, and gill rakers are rough, widely spaced, and range from 18 - 25. Some of these characteristics may change if subjected to an exotic habitat (Scott and Crossman 1973).

5.2 Distribution

Historical distribution of coho above IGD is not well known. Pre-dam investigations were focused on chinook salmon. The absence of coho sightings may be due to the earlier timing of surveys possibly missing later migrating coho. It is believed that the historical range of coho salmon below IGD included the mainstem Klamath River and tributaries including the Shasta and Scott rivers. The U.S. Forest Service (USFS) and CDFG have some information regarding presence and absence of juvenile coho salmon for many tributaries in the middle and upper Klamath River (CCFWO 1998). It is estimated that Shasta River presently maintains approximately 38 miles of coho habitat, which is below pre-development levels (Institute for Natural Systems Engineering 1999). Available data suggests that existing coho salmon habitat in the Scott River now constitutes approximately 88 miles (Institute for Natural Systems Engineering 1999). The cumulative effects of un-screened diversions, reduced flows, degraded spawning habitat, and high summer water temperatures have impacted anadromous fish production within these tributaries (Institute for Natural Systems Engineering 1999). The Yurok fisheries program and CCFWO have collected coho salmon outmigration data for tributaries in the lower Klamath River (CCFWO 1998).

5.3 Historical Run Abundance

Coho populations within the southern Oregon/northern California ESU are substantially below historic levels (NMFS 1995). In the California portion of the ESU, 36 percent of coho streams no longer have spawning runs (NMFS 1995). In 1983, the Service estimated the annual spawning escapement to the Klamath River system to range from 15,400 to 20,000 (USFWS 1983, cited in Leidy and Leidy 1984). CDFG (1994 as cited by Weitkamp et al. 1995) concluded that these estimates of coho abundance, including hatchery stocks, could be less than 6 percent of their abundance in the 1940's and have experienced at least a 70 percent decline in numbers since the 1960's. Recent coho returns have not been determined (Barnhart 1994).

Coho returns to Iron Gate Hatchery have been recorded since 1963, and have ranged from zero fish in 1964, to 2,893 fish in 1987. In 1997, 1,872 adult coho and 302 grilse returned to IGH (M. Pisano pers. comm. 1998). Coho returns to the Shasta River have been noted since 1934 (M. Pisano, CDFG pers. comm. 1995). The Shasta River data is limited since the weir is removed following the fall chinook run in late November. Coho continue to migrate up the Shasta River into late December, thus weir counts are incomplete. Based on these available data, Shasta River coho returns have been variable since 1934, and show a great decrease in returns for the past seven years (M. Pisano, CDFG pers. comm. 1995).

The decline of California coho salmon can be attributed to the following: stream alterations brought about by poor land-use practices, water development/diversions, the effects of periodic floods and drought, the breakdown of genetic integrity of native stocks, introduced diseases, over harvest, and climatic change (Brown et al. 1994). In separate petitions to NMFS, both Oregon Trout et al. (1993) and Pacific Rivers Council et al. (1993, cited in NMFS 1995) indicate freshwater habitat destruction as the primary cause for the decline in coho populations. Pacific Rivers Council et al. (1993) also cited deteriorating ocean conditions, adverse effects of artificial propagation, intraspecific hybridization and interspecific hybridization with chinook salmon (Pacific Rivers Council et al. 1993 cited in NMFS 1995).

Recent reviews of Klamath River coho populations have identified these as populations of special concern; populations are low, however they are not in immediate danger of extinction (Nehlsen et al. 1991, Higgins et al. 1992, Brown et al. 1994). The observation that coho populations in the southern Oregon/northern California area are depressed relative to past abundance, and noting the large amount of hatchery production which occurs in Oregon, suggests natural populations are not self-sustaining (NMFS 1995). Although not in danger of extinction, these populations are likely to become endangered if present trends continue (NMFS 1995).

5.4 Life History

Adult coho migrate into the Klamath River from mid-September through mid-January (Shaw et al. 1997, USFS 1972, cited in Leidy and Leidy 1984). Fish will hold in the estuary with upstream movement triggered by increased flows due to the fall rains (Scott and Crossman 1973). Upstream movement occurs during the day (Scott and Crossman 1973). Those fish destined for Iron Gate Hatchery first arrive in early October with the greatest number of fish arriving around the first of November (FishPro 1992). Coho returns to the hatchery extend into January.

Adult coho return primarily as 3-year-old fish although some will return as 2-year-old precocious males (jacks or grilse) (Leidy and Leidy 1984). The percent of jacks within a run can vary greatly year to year. Coho jacks are not sterile and can actively spawn and fertilize eggs. In some rare cases a female may return as a 2-year-old (Scott and Crossman 1973). In the Klamath system, coho normally spawn in tributary streams from November through January (Leidy and Leidy 1984). However, coho salmon have been observed spawning in side channels, tributary mouths and shoreline margins of the mainstem Klamath River between Independence and Beaver creeks (T. Shaw, pers. comm. 1996). Typically all returns to the Iron Gate Hatchery are ready to spawn by the first of January (Fish Pro 1992). Coho, like chinook salmon, die soon after spawning.

Once spawning is complete, eggs will incubate in the gravel for about seven weeks before hatching (Scott and Crossman 1973). The time period for egg incubation in the Klamath system is from November through March (Leidy and Leidy 1984, Weitcamp et al. 1995). Fish will remain in the gravel as alevins for about 2 to 3 weeks until the yolk is absorbed, then emerge as free-swimming, actively feeding fry (Scott and Crossman 1973). Emergence typically occurs from February to mid-May (Leidy and Leidy 1984, Weitcamp et al. 1995). The peak downstream movement usually occurs between April and May (Leidy and Leidy 1984).

In California, most young coho remain in freshwater for at least 1-year before migrating to the ocean (Moyle 1976). In some cases however, fry may migrate to the ocean without rearing in freshwater (Scott and Crossman 1973). Other fish may never migrate to the ocean, but become residuals which mature but never spawn (Scott and Crossman 1973).

Juvenile coho will initially take up residence in shallow, gravel areas near the streambank (Scott and Crossman 1973). Later in the summer fish will move into deeper pools seeking slow moving water and structure for cover.

Fish activity, feeding, and growth rates are dependent on water temperature. Preferred rearing temperatures of 12 to 14 ^{o}C (Bell 1990) allow fish to grow quickly as they feed primarily on insects (Scott and Crossman 1973). Young coho will also eat other smaller fish when available.

In the spring, following their first winter, yearling coho will leave their freshwater habitat and migrate to the ocean. The behavior of the fish is to travel in small schools mainly at night (Scott and Crossman 1973). Timing of migration varies between individuals based on physiological development and fish size, and other variables such as photoperiod, stream flows, and water temperature (Craig 1994). Rate of downstream migration appears to be related to size; larger fish travel faster (USFWS 1992).

Klamath River basin coho will outmigrate from February through mid-June (Leidy and Leidy 1984, Weitcamp et al. 1995). Trapping on the Klamath River mainstem at Big Bar during the spring of 1994 collected juvenile coho from March through June with peak numbers observed in mid-May (Craig 1994). Timing of the peak is consistent with observations from trapping conducted in 1988 and 1989 (USFWS 1992).

Size of migrating fish increases with later migration times. As yearlings, these fish are approximately 100 mm long when they begin their outmigration (Scott and Crossman 1973). Year-old coho collected at the Big Bar trap ranged in size from 100 mm to 190 mm and small young-of-the-year coho ranged from 44 mm to 90 mm (Craig 1994).

Peak numbers of coho smolts generally arrive into the Klamath River estuary in April and May (Wallace 1994). The number of fish declines to low levels after May and remains low until October or November (Wallace 1994). Coho captured in the spring appeared to be smolts, while fish collected in the fall were young-of-the-year parr (Wallace 1994).

5.5 Reproduction

Hatchery reared coho adults that return to spawn in the Klamath system are primarily 3-year-old fish. The jack component of the run can be variable and has ranged from zero to 79 percent. Adult size may vary based on ocean conditions and run timing. In 1993, female adults returning to Iron Gate Hatchery typically ranged from 52 cm to 74 cm (FL) (K. Rushton, CDFG pers. comm. 1995). In the same season males ranged from small jacks at 41 cm to 70 cm FL (K. Rushton, CDFG pers. comm. 1995). Average number of eggs per female collected at the Iron Gate Hatchery is 2,660 eggs (K.

Rushton, CDFG pers. comm. 1995).

Spawning activities follow the pattern of other salmonid species. In initiating spawning, the female fish selects a site in the stream where the stream bottom is of medium to small gravel and the current swift. At this location, the fish will excavate a long oval to round trough where the female will deposit her eggs. Van Den Berghe and Gross (1984) found nest depth to be related to fish size; larger females buried eggs as much as 2.5 times deeper than small females. The range of nest depths observed in the study was from 8.9 cm to 26.7 cm (Van den Berghe and Gross 1984). Once the eggs are extruded from the female, an adjacent male or males (including jacks) releases sperm fertilizing the eggs. To secure and protect the eggs, the female will dig upstream covering the eggs with gravel. Large female coho may spawn up to four times in different nests, however most females spawn two times (Van Den Berghe and Gross 1984). Post-spawning, female fish will guard the redd until they die.

Development of the eggs is dependent on environmental factors, the most obvious is water temperature. With stable water temperatures of 8.9°C coho eggs can hatch in 48 days (Scott and Crossman 1973).

6.0 EFFECTS OF KLAMATH PROJECT ON COHO SALMON IN THE KLAMATH RIVER

6.1 <u>Relationship between Macrohabitat and Microhabitat</u>

Reclamation has been actively involved since 1998 in developing analytical tools to evaluate potential impacts to coho salmon and other salmonids from flow- related changes in the mainstem Klamath River resulting from operation of the Project.

To date a number of hydrology-based methods, such as the modified Tennant method used by Trihey and Associates on behalf of the Yurok tribe and the USU - Hardy Phase I study, have been employed to determine an instream flow regime that would protect coho, chinook, and steelhead spawning, rearing and egg incubation.

Hydrology-based methods implicitly assume that macrohabitat conditions such as water temperature and dissolved oxygen are not limiting in the longitudinal reach of the Klamath River. Dr. Hardy acknowledges the limitation of the hydrology based methods in the Phase I report as presented with the following. *"At this juncture, the various techniques employed implicitly assume that other factors such as water quality or temperature are not limiting. This of course is not true for the mainstem Klamath River below Iron Gate Dam where deleterious water temperatures and low dissolved oxygen have been associated with fish kills during the late summer low flow period"* (Institute for Natural Systems Engineering 1999).

To help address this limitation, Reclamation has cooperated in development of field based methods (Phase II) by Dr. Hardy. Phase II relies on field based quantitative models, rather than hydrology based approaches, to determine availability of total habitat (macrohabitat and microhabitat) for incremental changes in river flow.

The Phase II analytical tools will be available at a later date. Once available, this science will be the best available science and will be used to evaluate the proposed Project operations, as suggested by NMFS (Reck D. per. com 2000).

The Proposed Action includes a concept to explore ways to minimize depressed flows during certain periods in the spring (see Section 4.2). This concept may ameliorate the impacts of stranding fish when flows are dramatically dropped during this period in certain years (see Figure 2 for example).

6.2 Klamath River Water Temperature and Discharge

Water surface temperatures in the Klamath River basin typically range from 0^{o} C (32^{o} F) to 30^{o} C (86^{o} F) throughout the year (Deas 2000 a, Bartholow 1995). Average daily water temperatures in the IGD to Seiad Valley reach may fall below 10^{o} C (50^{o} F) during winter months and can exceed 25^{o} C (77^{o} F) by mid-summer. Daily average water temperatures typically decline below 16.0^{o} C (60.8^{o} F) by early October. Seasonally the diurnal range in water temperature is greatest in the summer and smallest in winter.

Table 4 is a summary of mean hourly water temperatures and discharge averaged over various time steps based on data collected by Reclamation in 1999. Klamath River water temperatures exceeded 20^{o} C in July and August. The highest average temperature in the1999 field season was 21.72 ^{o} C with a corresponding average discharge of 1,561 cfs at Seiad Valley (Table 4). These water temperature data appear to be consistent with the modeling effort by Deas (2000 a) and the analysis by Bartholow (1995).

Deas and Orlob (1999) measured hourly water temperature at several locations in the Klamath River between IGD and Seiad Valley. Observations below the Shasta River for the period June 6 - October 1 1997 show that the diurnal temperature range (difference between the daily maximum and minimum) varies seasonally. The diurnal range was about 5^{o} C by mid-summer, then decreased to about 2^{o} C by mid-October (Figure 7.16 in Deas and Orlob 1999).

Young of the year survival, growth, and recruitment depend on the availability of total habitat including suitable macrohabitat (water quality and temperature) and suitable microhabitat (depth, velocity, and cover) conditions under different river flows. The availability of suitable microhabitat may not be a primary factor in the survival of YOY salmonids when acute water temperatures prevail. Chronic (>15^{o} C) and acute (>20^{o} C) water temperatures create a population bottleneck by impacting YOY and juvenile coho from late June through September (Table 4).

Table 4. Klamath River water temperatures. Information derived from Reclamation water quality study in 1999.

Klamath River Below Iron Gate				Klamath River Nr. Seiad			
Semi-Monthly Period	Average Temp. (° C)	Average Temp. (° F)	Average Flow Data (CFS)	Semi-Monthly Period	Average Temp. (° C)	Average Temp. (° F)	Average Flow Data (CFS)
5/1-5/15	11.64	52.95	3,489	5/1-5/15	11.45	52.60	6,894
5/16-5/31	12.92	55.26	2,668	5/16-5/31	13.55	56.39	7,003
6/2-6/15	16.76	62.17	1,920	6/1-6/15	14.54	58.16	5,223
6/16-6/30	18.36	65.05	1,953	6/16-6/30	17.79	64.02	4,708
7/1-7/15	20.34	68.62	1,353	7/1-7/15	20.23	68.41	2,505
7/16-7/31	20.76	69.37	1,310	7/16-7/31	na	na	1,911
8/1-8/15	21.34	70.41	1,125	8/1-8/15	21.59	70.86	1,591
8/16-8/31	21.01	69.82	1,148	8/16-8/31	21.72	71.10	1,561
9/1-9/15	19.57	67.23	1,323	9/1-9/15	19.49	67.07	1,610
9/16-9/30	18.47	65.24	1,371	9/16-9/30	18.41	65.15	1,736
10/1-10/15	16.43	61.57	1,390	10/1-10/15	15.84	60.51	1,712
10/16-10/31	13.86	56.96	1,490	10/16-10/31	12.60	54.67	1,906
11/1-11/15	11.64	52.95	1,818	11/1-11/15	11.70	53.06	2,510
11/16-11/30	10.06	50.10	1,818	11/16-11/30	9.46	49.02	2,579

Note: All Flow Data Matches Temperature Data Time Period Samples

River flow can directly impact water temperatures in the Klamath River (Deas 2000 a). Preliminary flow and temperature simulations in the sixty-mile reach from IGD to Seiad Valley suggest that during summer periods lower flows generally lead to higher downstream temperatures. Simulated temperature response for a typical mid-summer day at various IGD releases illustrates the flow-temperature interdependence. At 500 cfs, simulated daily mean water temperature increases 2.5 ° C (4.9 ° F) over the sixty mile reach from IGD to Seiad Valley, while at 3,000 cfs the simulated increase is roughly 0.9 ° C (1.6 ° F) (Table 5) (Deas 2000a). Water temperatures are elevated at low flow rates because of an increase in transit time, less thermal mass allowing greater heating during the day, and shallower river conditions. At 500 cfs, a mean simulated temperature of approximately 25 °C was recorded at Seiad Valley, compared to about 23.0 °C at 3,000 cfs in mid-August (Figure 17 in Deas 2000a). Thus, high water temperatures can occur at high and low flows, depending on climatic conditions. The extent to which Project operation affects water temperature is complex and remains unclear (Balance Hydrologics 1996). Available information suggests that Project flows may not influence temperatures dramatically in the Klamath River at Seiad Valley.

One limitation of the temperature modeling is described by the Institute for Natural Systems Engineering (1999), "*At low flow rates water temperature results are compromised due to physical representation of river geometry where modeled flows are excessively shallow due to fixed trapezoidal cross sections. Maximum daily temperatures are probably too high and minimums too low for flows < 500 cfs. Mean temperatures are probably representative*."

Table 5. Simulated effects of river flow on water temperature in the Iron Gate Dam to Seiad Valley reach of the Klamath River for a typical mid-summer day.

Simulated Iron Gate flow in cubic feet per second (cfs)	Simulated net temperature increase in the Iron Gate Dam to Seiad Valley reach in ^{o} C and (^{o} F)
500 cfs	2.5 ^{o}C (4.5 ^{o}F)
1000 cfs	2.1 ^{o}C (3.8 ^{o}F)
2000 cfs	1.3 ^{o}C (2.3 ^{o}F)
3000 cfs	0.9 ^{o}C (1.6 ^{o}F)

Diurnal water temperatures including maximum and minimum values are also affected by flow regime. For low flows, daily maximum temperatures are higher and daily minimum water temperatures are lower, while at higher flows water temperature daily maximums are lower and minimum temperatures higher (Institute for Natural Systems Engineering 1999).

6.3 Water Temperature and Salmonid Physiology

Temperature has direct effects on physical, chemical, and biological processes in most aquatic systems. High temperatures increase chemical reactions, metabolic rates, and decrease the solubility of gases such as oxygen, carbon dioxide and nitrogen (Deas 2000 a). Excessive water temperature can reduce productivity and increase mortality of aquatic organisms. Temperature affects fish physiology, specifically respiration, food intake, digestion, assimilation, and behavior.

Young of the year (YOY) survival, growth, and recruitment depend on the availability of total habitat, including suitable macrohabitat (water quality and temperature) and suitable microhabitat (depth, velocity, and cover) conditions under different river flows. The availability of suitable microhabitat may not be a primary factor in the survival of YOY salmonids when acute water temperatures prevail. Chronic (>15^o C) and acute (>20^o C) water temperatures create a population bottleneck by impacting YOY and juvenile coho June to September (Table 4).

Temperature impacts are well documented for anadromous and resident salmonids, particularly chinook salmon and rainbow trout. Temperature requirements vary by life stage with the adult life stage more tolerant to higher temperatures than incubating eggs, larvae, and juveniles.

Adult spring chinook were observed in water temperatures approaching 26^o C in the John Day River (Torgersen et.al 1999). Persistence of these fish in the John Day River at ambient water temperatures exceeding the thermal optima cited for spring chinook migration (16^o C) and spawning (14^o C) and the upper zone of thermal tolerance (22^o C) (Bell 1986, Armour 1991, Bjornn and Reiser 1991) limits suggest some sort of behavioral adaptation at work.

Studies of spring chinook with temperature sensitive radio transmitters in the Yakima River indicate spring chinook behaviorally thermoregulate to maintain internal temperatures 2.5^o C lower than ambient stream temperatures in surrounding habitats (Berman and Quinn 1991). Although different races of chinook salmon have been widely studied with regards to temperature, separate thermal tolerance criteria have not been developed. Studies on Klamath River stocks regarding their ability to acclimate or genetically adapt to temperature conditions have not been done. Controlled laboratory experiments are needed on the physiological response of Klamath River chinook juveniles to elevated water temperatures (Williamson and Foott 1998).

Only recently, since the early 1990s, have affordable instantaneous temperature measuring devices been available. Thus, field studies on diurnal temperature effects on fish have not been done. This is an area that needs further study (M. Deas and T. Shaw, per. comm. 2000).

In the absence of information on diurnal temperature effects, temperature acclimation studies provide some indication of effects of temperature changes on fish. Armour (1991) studied the acclimation effects in juvenile chinook salmon and found fish subject to higher initial water temperature could sustain higher maximum temperature than those acclimated to cold water (Table 6). The data suggest that, even if fish are acclimated to 20° C, you can expect 50% mortalities if temperatures reach 25.1° C during the day.

Table 6. Acclimation response for juvenile chinook salmon (Armour 1991).

Acclimation Temperature ° C (° F)	Temperature at 50 % Mortality	
	Lower ° C (° F)	Upper ° C (° F)
5.0 (41.0)	-	21.5 (68.9)
10.0 (50.0)	0.8 (33.4)	24.3 (75.7)
15.0 (59.0)	2.5 (36.5)	25.0 (77.0)
20.0 (68.0)	4.5 (40.1)	25.1 (77.2)

Myrick (1998) evaluated the effects of temperature, ration level, and genetics on the physiology of four strains of juvenile rainbow trout (*Oncorhynchus sp.)* by measuring growth rates, food consumption, acute upper thermal tolerance, oxygen consumption, swimming performance and thermal preference. Thermal responses of Eagle Lake rainbow trout (*O. m. aquilarum*), Mt. Shasta rainbow trout (*O. mykiss*), and Little Kern golden trout (*O. m. whitei*) at temperatures of 10, 14, 19, and 25° C while receiving ad libitum rations were studied. Investigations were also conducted evaluating the physiological responses of juvenile Central Valley steelhead (*O. m. irideus*) to the combined effects of water temperature (11, 15, and 19° C) and ration levels at 100 % ad libitum, and 80% ad libitum.

Eagle Lake trout, Mount Shasta rainbow, and Golden trout exhibited a higher upper critical maxima than Central Valley steelhead. Eagle Lake rainbow trout upper critical thermal maxima (CMT) with loss of equilibrium ranged from 27.6° C to 32.0° C. Mount Shasta rainbow exhibited a loss of equilibrium at temperatures ranging from 27.7° C to 31. 5° C, and Golden trout CMT ranged from 27.69° C to 29.95° C. Age 0 winter-run Central Valley steelhead CMT ranged between 27.8° C and 29.9° C depending on acclimation temperatures and ration size (reduced versus full ration). Central Valley juvenile steelhead preferred temperature ranges between 17° and 20° C with a mean preferred temperature of 18.3EC.

Acclimation temperature affected the upper critical thermal tolerance with thermal tolerance increasing with higher rearing/acclimation temperature. Other studies also indicate an increase in thermal tolerance at higher acclimation temperatures (Myrick 1998 cited from Cherry et al., 1975; Kowalski et al., 1978; Lee and Rinne, 1980; Elliot, 1991). Under natural conditions, fish that lose their equilibrium due to thermal stress are no longer capable of evading the thermal stressor and are considered imminent mortalities.

Little information is available on coho salmon temperature tolerance. Preferred temperature ranges for migration, spawning, egg incubation, and juvenile rearing are presented in Table 7. Studies by Konecki et al (1995) of juvenile coho salmon near St. Helens Washington found juvenile coho could tolerate water temperatures exceeding 24° C (75.2° F) and in some cases were observed in streams with temperatures as high as 29° C (84.2° F).

Table 7. Coho salmon temperature tolerance (Reiser and Bjorn (1979), Birk (1996), and Hassler (1987)).

Life Stage	Preferred Temperature ° C (° F)		Upper Limit ° C (° F)
Migration	7.2 - 15.6 (45.0 - 60.1)	Hassler (1987) 4.0 -14.0 (39.2 - 57.2)	Hassler (1987) 25.5 (77.9)
Spawning	4.4 - 9.4 (39.9 - 48.9)	6.0 - 12.0 (42.8 - 53.6)	25.8 (78.4)
Egg Incubation	4.4 - 13.4 (39.9 - 56.1)	4.4 - 13.3 (39.9 - 55.9)	n/a
Juvenile Rearing	11.8 - 14.6 (53.2 - 58.3)	4.4 - 9.4 (39.9 - 48.9)	25.0 (77.0)
Juvenile Outmigration (Birk)	7.2 - 16.7 (45.0 - 62.1)	4.4 - 9.4 (39.9 - 48.9)	25.0 (77.0)

6.4 Water Temperature and Fish Diseases

Spawning adults are susceptible to lethal disease at temperatures exceeding 16.0° C (60.8° F) (Armour 1991). Boles (1998) found juvenile salmon more susceptible to diseases, parasites, and predation at temperatures above 15.5° C (59.9° F). Klamath juvenile salmonids have evolved some resistance to *Ceratomyxa shasta* when water temperatures are below 16° C (Foote et al. 1999).

However, these fish exhibited very high mortality rates from *C. shasta* at higher temperatures.

Ceratomyxosis is one of several significant infectious disease in the Klamath River (Hendrickson et al. 1989 cited in Foote et al. 1999). Elevated water temperatures, often in excess of 18^{o} C during the late spring and summer have been identified as a negative factor for anadromous fish in the Klamath River (Klamath R. Basin Fish Task Force 1991, cited in Foott et al. 1999). Foote et al. (1995) examined Iron Gate Hatchery chinook juveniles captured in the mid-Klamath River (Indian and Red Cap Creeks, Orleans, and Big bar) during both their spring and autumn releases in 1995.

Infectious disease significantly affected the survival of juvenile chinook (broodyear 1994) released from the Iron Gate Hatchery in 1995 (Foote et al., 1999).   Ceratomyxosis was prevalent in the June release of chinook juveniles with a high of 92% incidence of infection occurring in the third week after release.   This parasitic infection was associated with intestinal hemorrhage, anemia, and high mortality. Elevated river temperatures appear to exacerbate the disease as IGH stock tends to be resistant to *C. shasta* at temperatures # 16^{o} C.   Pancreatitis and inflamation of the associated adipose tissue occurred in the majority of June out-migrants. Energy reserves were depleted in the June release group but to a lesser degree in the November release fish. The health and condition of the June released chinook juveniles captured at Big Bar (July 18) dramatically improved five weeks after release. River temperatures were above 20^{o} C during this period, thus demonstrating that high temperature at the capture site and poor fish health are not always related.   Foote et al. (1999) speculated these outmigrants may have been holding in cool-water refugia and now were rapidly moving out of the system to the estuary.

Crucial characteristics, such as immune defenses, metabolic scope of activity, and smolt development would be expected to be significantly impaired by long term exposure to elevated temperatures. Consequently, thermal refugia appears to play a significant role in the mainstem Klamath River and/or fry and juveniles rear in cooler water tributaries as they migrate down river to escape the inhospitable temperature conditions typical of the mainstem river in the summer.

A fish kill involving juvenile chinook salmon and steelhead occurred in the Klamath River between Happy Camp and Salmon Creek (Coon Creek) confluence in June 2000 (M. Pisano, CDFG, per. comm., 2000). A large pulse of fish documented between June 18 and July 1 was dominated by chinook salmon smolts released by Iron Gate Hatchery between June 9 and June 11 (Buettner 2000). Two pathogens were found in dead fish, *C. shasta* and *Flexibacter columnaris.* Deas (2000 b) summarized hydrologic, meteorologic, and water temperature data during this period. He concluded that during the period June 15-July 7, 2000 persistent warm conditions dominated the region. There was an apparent relationship between flow and temperature in the mainstem Klamath River in the area of the fish kill. At lower flows, transit time increased, leading to the potential for increased thermal loading. Flows near Seiad Valley declined from approximately 3,000 cfs on June 15 to about 1,500 cfs by July 1, with over 60% of the decrease occurring by June 21 (Deas 2000 b). Warm conditions probably accelerated the runoff from snowmelt, leaving less water in tributaries to ameliorate mainstem conditions (temperatures and flows) by late June. Also, tributaries were probably warmer than normal due to lower flows and associated increased transit times. Dissolved oxygen did not appear to be a water quality concern (Deas 2000 b). Water temperature reached a peak of 24.03° C the afternoon of June 29 at Big Bar (River Mile 50) on the Klamath River (Craig 2000).

Other major fish kills have been documented in 1994, 1995, and 1997 (T. Shaw, Fish and Wildlife Service, per. comm., 2000). Heavy algal loads and high water temperatures likely cause fish deaths that are observed annually around mid-August in traps monitored by the Service (T. Shaw, Fish and Wildlife Service, per. comm., 2000).

6.5 Microhabitat - Edge Habitat

Total available habitat is computed by combining macrohabitat such as water quality and temperature combined with microhabitat (depth velocity, cover). Cover such as edge habitat, undercut banks, and overhanging vegetation provide essential velocity shelters, protection from predators and an important source of terrestrial insects for food.

Habitat events affect recruitment via habitat types directly related to the production and survival of eggs, larvae and fry. Chronic and acute water temperatures during the summer effectively reduce macrohabitat availability and override benefits derived from the microhabitat component.

“Habitat bottleneck” refers solely to habitat limitations that affect populations of individual species. The basic premise is that populations of aquatic organisms are related to the availability of habitat through time. Adult populations are frequently determined by recruitment which is highly correlated to the amount of habitat (microhabitat and macrohabitat) for early life stages of the species.

The most critical period for YOY salmonids occurs in March, April, May, and early June (Tom Shaw, per. comm. 1998). YOY begin to emerge from the spawning redds and seek out stream margins providing vegetated cover which in turn providing low velocity envelopes, protective cover from predators and sources of food. Phase II results should provide further information regarding edge habitat needs for YOY salmonids.

Klamath River chinook fry (FL < 55 mm) show a distinct preference for object and overhead cover associated with edge habitat. Chinook fry preferred escape cover consisting of grasses, sedges, and herbacous plants and multistem shrubs. Chinook fry are typically found within 1.0 feet of escape cover.

6.6 Rearing Habitat

Higher summer river flows generally create more rearing habitat for juvenile salmonids than lower flows (Bjorn and Reiser 1991; Binns and Eiserman 1979; Havey and Davis 1970; Matthews and Olson 1980 as cited in Satterthwaite 1987). The relationship of high river flows in the spring and summer and availability of rearing habitat has been well documented over the last 30 years of instream flow studies in the United States. The underlying assumption for all instream flow studies are based on the longitudinal distribution of suitable macrohabitat (channel characteristics, water quality, and water temperature) and available microhabitat as a function of discharge. Water quality and water temperature must be suitable throughout the reach of river or stream for the target species under investigation. Higher flows in the Klamath River may not provide more rearing habitat as observed in other salmonid systems because of problems with high summer water temperatures, depressed dissolved oxygen levels, and fish pathogens. Various Project operational scenarios may provide limited improvements in temperatures as well as increased microhabitat.

The longitudinal distribution of YOY salmonids in the Klamath River and selection of cooler thermal refugia areas near tributary mouths compared to warmer mainstem environs implies some avoidance where temperature may affect survival. Suboptimal temperatures, even though nonlethal, may significantly reduce fish production.

Experiments with pulse flows in 1994 indicate higher flows (1,500 vs 1,000 cfs) over a two day period benefitted hatchery fish by helping to decrease travel time to the Big Bar area. Reduced travel time has been shown to increase survival by decreasing the amount of time fish are subjected to in-river predation, disease, and stress and/or mortality associated with increasing water temperatures in the river (Craig 1994).

Size of fish at time of release also plays an important role in migrational timing. Larger YOY chinook marked with adipose clips and coded wire tags migrated at faster rates than smaller fish. Craig (1994) reported a two day pulse flow of 1,500 cfs in June 1994 increased transient time of hatchery release YOY chinook downriver to the Big Bar area.

6.7 Iron Gate Dam Ramping Rates

The 1999 BO for Reclamation's Klamath Project Operations identified that the rate of flow reduction (down ramping) at Iron Gate Dam may be a potential cause of fish stranding downstream in the Klamath River during down-ramping. In this BO, NMFS acknowledged "that there is an intimate operational relationship between the Project and PacifiCorp facilities" and that "associated, intimately-involved IGD operation by PacifiCorp is authorized by this incidental take statement." As such, Term and Condition 2 in the BO stated that in coordination with PacifiCorp, Reclamation would conduct a study to determine the effects of PacifiCorp's FERC ramp rate on fish resources below IGD. This study was carried out in 1999 and the results are described in Hardin Davis, Inc. (2000). The main conclusions of this study are summarized below.

Results of 1999 IGD Ramp Rate Study (Adapted from Hardin-Davis, Inc. 2000)

1. PacifiCorp has accurate control over ramping at Iron Gate Dam at flows below 1735 cfs. Ramping at flows above 1735 cfs must be controlled at Copco, and the degree of control is much less.
2. Past ramping by PacifiCorp has nearly always met current license restrictions. It has also met generally accepted agency guidelines for hourly down-ramping almost all the time. When flows were below 1800 cfs at the gage, ramp rates were below 1.0 inch per hour, and below 100 cfs per hour about 97% of the time. At this same flow range, ramp rates were less than 2

inches per hour about 99% of the time. When Iron Gate was spilling, at flows above 1800 cfs at the gage, the results were similar. The maximum down-ramp rate in cfs was higher during spill operations, but this did not translate into a frequency of events of 2 inches or more because cfs change required to cause a 2-inch stage change increases at higher flows.

3. Results from the hydrodynamic model and from the pulse flow study suggest that the magnitude of a stage decrease per hour reduced by about half at a distance 50 miles down from IGD. The variables affecting the zone of influence are total flow, ramp rate, and tributary inflow.
4. The existing data did not identify specific areas of potential stranding habitat. However, the amount of potential stranding habitat (e.g. side channels) appears to be less between IGD and the Shasta River confluence; the reach where ramping rates at IGD are expected to have the greatest impact on river stage changes.
5. During the only reported incidence of stranding, the 1998 Tree of Heaven Event, major flow decreases (>2000 cfs) occurred over 1-3 day periods. The flows during this time exceeded the Iron Gate turbine capacity. Current channel morphology at the Tree of Heaven site is the result of significant past alteration by human activities.

   Based on the conclusions of the Hardin-Davis ramp rate study, the following steps were implemented in order to minimize and mitigate for any potential impacts of flow reduction (fish stranding) at Iron Gate Dam in 2000. As in 1999, PacifiCorp's year 2000 operation of IGD subject to these requirements should be sufficient to authorize its operation of IGD under Reclamation's incidental take statement.

6. PacifiCorp shall target a down-ramp rate below IGD of 150 cfs per hour when the facility is not spilling. At flows above 1735 cfs, PacifiCorp will follow the current FERC ramp rate during spill. The FERC ramp rate is 3 inches per hour or 250 cfs per hour, whichever is less "except for conditions beyond the control of the Licensee (FPC 1961)."

7. PacifiCorp shall cooperate with CDFG to eliminate the potential for stranding from the documented stranding site known as Tree of Heaven. This will be done by on-the-ground manipulation of the point bar.

6.8 <u>Klamath River Flows 1992 - 1994 and Fall Chinook Escapement 1992 - 1997</u>

The habitat requirements for chinook salmon and steelhead life stages, although somewhat different than coho salmon can be used as a surrogate for coho because of the paucity of information on coho salmon in the Klamath River watershed. Chinook and steelhead prefer faster and deeper water for spawning than coho salmon. However, all three species represented by the YOY and juvenile life stages depend on edge habitat for velocity shelters, protection from predators, and food sources.

Given the lack of information on coho salmon, general trends in chinook salmon populations and their response to changes in mainstem macrohabitat and microhabitat conditions may provide a good approximation of the expected coho salmon responses to these changing conditions.

Klamath Chinook adult returns typically consist of five age classes but are dominated by 3 and 4 year old fish. Historical Klamath runs consisted of 6 year classes (Fortune et. al. 1966).   Fall run escapement to the Klamath River above the Trinity River confluence in 1995 and 1996 represented the highest returns since 1986-1988 but still well below historical levels. The number of fall chinook returning to the Klamath River has declined considerably since the 1960's. Fall chinook escapement consisted of stocks from Iron Gate Hatchery, and wild stocks from Bogus Creek, mainstem Klamath River, Salmon, Scott, and Shasta Rivers.   Habitat loss in the mainstem and tributaries from logging, water diversions, mining, elevated water temperatures, and poor water quality have all contributed to the decline of chinook, coho, and steelhead.

There has been some speculation that the relatively high returns observed in 1995 and 1996 were representative of freshwater conditions in 1992 and 1994. The relative strength of the adult returns in both years may be accurately attributed to very good ocean conditions and excellent microhabitat rearing conditions in the Klamath River in 1993.   Despite drought conditions in 1992 and 1994, it appears high flow conditions in the mainstem and tributaries in 1993 compensated to some degree for the poor microhabitat and macrohabitat conditions in the watershed below IGD in 1992 and 1994.

6.9 Water Quality Models

The HEC5Q, and SMA-11 models were used by Reclamation to assess the impact of Project Operations on water quality in the IGD to Seiad Valley reach of the Klamath River.   HEC5Q was used to compute the temperature of release water from Iron Gate Dam using an average daily time step. The SMA-11 model was used to compute Klamath River water temperatures in August using an hourly time step.

6.9.1 HEC5Q Water Quality Model

The period of record for all model runs was water years 1961-1997. Input flow data for the HEC5Q model runs was obtained from the KPOPSIM simulations and subsequently the MODSIM outflow data. The assumptions and conditions assumed in the KPOPSIM and MODSIM simulations are not presented here, only the assumptions pertinent to the HEC5Q model runs.

SIAM Multiple Year Model Assumptions

The SIAM Model developed by the USGS was used in making the water quality runs on the Klamath River. Within SIAM is the MODSIM and HEC5Q models. Binding the models and data is the user interface for SIAM which tracks the options that are to be simulated, passes data and simulation results as necessary to the appropriate models, and summarizes the output for convenient display. USGS staff in late 1999 modified the earlier version of SIAM to enable identification of a range of years for a simulation. That range can be as short as one year or as long as the entire period of record. SIAM was also modified to allow selection of meteorological data either to match the flow data years or to evaluate different sets of flow and meteorology. For example, selection of a critically dry year such as 1992 and the meteorology for 1996 is now possible. Synthetic meteorological data, if available, may also be used.

The HEC5Q, water quality component does not have the capability to perform true multiple year simulations. However, within SIAM, flow and meteorology data are provided to HEC5Q in sequence with the previous year’s ending simulation results forming the next year’s initial conditions. Therefore, in multiple year simulations in HEC5Q, the initial water quality for each reservoir at the start of each year is a single value equal to the reservoir discharge water quality for the last day of the previous year□s simulation. Each reservoir is assumed to be completely mixed at this point resulting in homogeneous water quality throughout the water column. The output from the HEC5Q model within SIAM is a 360-day simulation (twelve 30-day months) of average daily temperature (EC) and dissolved oxygen concentration (mg/L). The computation of daily flows for HEC5Q in cfs from the MODSIM output in acre ft per month does, however, use the traditional calendar for the number of days per month. These calculated flows are simulated for 30-day months by HEC5Q. SIAM formats the output data file to insert five blank days at the end of each year simulated, i.e., days 1-360 are model output, days 361-365 not predicted, day 366 is the first day of the following year. Thus, all years in the formatted output file are 365 days in length.

<u>Methods and Assumptions for Historical Meteorology (1961-1997)</u>

There are several weather site locations throughout the basin, such as Klamath Falls, OR, Medford Jackson County, OR and Montague-Siskiyou, CA airports; the Medford Jackson County, Oregon record being the most complete for the period of record desired for model simulations. However, there were significant differences between the Medford weather data and the Montague-Siskiyou data. Weather data and estimate of cloud cover based on precipitation and visibility from Montague-Siskiyou airport had been used for calibration and validation of the water quality component (HEC5Q) of SIAM prior to these recent simulations (Hanna, 1995a and 1995b). Therefore, the Medford Jackson County airport, OR data set was adjusted to more closely emulate the Montague-Siskiyou data set by comparing data for both weather stations from January, 1994 through December, 1998. The annual average air temperature, dew point, wind speed, and cloud cover for both locations were computed. An adjustment factor was applied to the Medford data to create an annual average value for each of these parameters identical to the Montague-Siskiyou values. The adjustment factors used to modify the Medford data to be applicable in the Klamath River basin were:

_ Decrease Medford Jackson County air temp by 3.4° F.
_ Decrease Medford dew point by 7.7 ° F.
_ Increase Medford wind speed by 0.36 mi/hr.
_ Increase cloud cover by 1.3 tenths.

The resulting meteorological database was used consistently for all requested flow scenario simulations.

<u>Flow Scenario Simulation Methods and Assumptions</u>

The MODSIM output data files used for SIAM water quality simulations were as follows:

1) ferc_esa.xy for the FERC release schedule at Iron Gate Dam scenario,

2) esa_fp1.xy for the USU Phase I report recommended minimum instream flows at Iron Gate Dam scenario, and

3) no_proj.xy for the without dam or irrigation project river flow scenario.

HEC5Q requires a set of inflow water quality conditions for each year simulated. That water quality data set is currently used for all inflows and accretions throughout the model domain for the simulation except Big Springs. The Big Springs accretion below JC Boyle reservoir is an exception and is specifically characterized. This inflow is modeled to enter at river mile 224.5 and supply a constant 100 cfs that varies from 11 - 15^{o} C throughout the year. The measured 1996 water quality data record at Keno was used to characterize inflow water quality for the simulations identified above. In the final contract completion report, it was indicated that USGS had explored the possibility of synthesizing inflow water quality by calculating the equilibrium temperature from the historical Medford meteorology database using the Corps of Engineers HEATX model that is provided as a part of the suite of models for HEC5Q. The resulting equilibrium temperatures were averaged by either a 20-day or a 30-day running average and substituted for the 1996 Keno water quality data set. USGS found that neither method resulted in a significant improvement in the error statistics compared to using the Keno, 1996 data set. Therefore, the Keno, 1996 data set was used for all flow scenario simulations. It may be possible to improve the inflow water quality characterization for the historical period of record, but additional data and time would be required to allow this estimation process to occur.

Meteorological and Hydrological Year Type Determination

Individual year simulations that mix and match meteorological and hydrological year types are based on the meteorological year types, hot, cool, and median; and the hydrological year types, wet, average and dry. The adjusted Medford air temperature data base was statistically evaluated and the average air temperature for the April 1 - September 30 period of each year was used as a metric for categorization into hot, median and cool meteorologic year types. The years: 1992, 1964, and 1979 correspond to the hot, cool, and median meteorological year types, respectively. Selection of hydrological year types was performed in coordination with Reclamation Klamath Area Office and Denver TSC staff. The total Upper Klamath Lake inflow for April through September of each year was evaluated and used in the hydrologic categorization. The years 1983, 1989, and 1992 correspond to the wet, average, and dry hydrological year types, respectively as summarized below. The final contract completion report provides a list of the data used for determining meteorological year types and also provides a list of the data used for determining hydrological year types.

Summary of meteorological and hydrological year types.

Meteorological category	Hydrological category
hot (1992)	dry (1992)
median (1979)	average (1989)
cool (1964)	wet (1983)

No Irrigation Project Model Methods and Assumptions

The HEC5Q model application for this scenario was developed to expand the model domain upstream from Keno, Oregon to Upper Klamath Lake, Oregon, which is now the upstream boundary/reservoir for the without irrigation project model. Simplified bathymetry of Upper Klamath Lake was included in the model and the source for bathymetric data was an elevation/storage/surface area table for the lake. The elevation of Upper Klamath Lake dam outlet in this HEC5Q model application is 4139 ft which is the same elevation of the minimum Upper Klamath Lake elevation used by KPOPSIM. Note that this elevation is higher than the original reef elevation before excavation of the channel at the Upper Klamath Lake outlet and simply signifies the minimum lake level for the KPOPSIM simulations. River bed elevations from USGS gage records were used and the channel shape for the river reach between Upper Klamath Lake and Keno was estimated at a bottom width of 78 ft and a side slope ratio of 3:1 (trapezoidal cross section). Data characterizing channel shapes for the reach between Upper Klamath Lake and Keno were unavailable. All downstream reservoirs in the HEC5Q model domain were removed. The inflow water quality used was the Keno, 1996 data set, as discussed above. The basin-wide flows were obtained from the no_proj.xy MODSIM file. It should be noted that in the MODSIM application that the downstream reservoirs, J.C. Boyle, Copco, and Iron Gate remain in the model with a small capacity (1 acre-foot) that is held constant throughout the simulation. This inclusion of the reservoirs in the water quantity model simulation does not effect the water quality model prediction. The meteorology used for this simulation was the adjusted Medford data set previously discussed.

The resultant model runs were provided to Dr. Hardy in January 2000 for use in the PHABSIM and bioenergetic modeling for Phase II. Water quality modeling (HEC5Q) indicated changes in reservoir management such as maintaining maximum storage capacity in the spring may reduce IGD outfall water temperature slightly (1-3^{o} C). The HEC5Q results were not comparable to the modeling results of Deas (2000 a) because of different objectives. The HEC5Q model was used for general planning purposes with longer flow time steps, whereas the Deas (2000 a) study was more detailed and used shorter time steps in a shorter reach of river (60 miles) (M. Deas, per. comm. 2000).

7.0 CUMULATIVE EFFECTS

Cumulative effects of State and private activities on anadromous fish species in the Klamath Basin appear significant. Since 1906, the fish habitat conditions throughout the watershed including headwater streams, Upper Klamath Lake (UKL), the Klamath River from Link River Dam to Klamath California, IGD and tributaries below IGD have been altered by human activities throughout the basin. The Klamath Project has altered UKL elevations and Klamath River flows below IGD. Marsh lands surrounding UKL have been converted to agricultural use reducing the capacity of the lake to reduce nutrient levels.

Klamath River anadromous fisheries have declined precipitously since the early 1900's. Steelhead and chinook salmon above the Trinity River were determined by NMFS to not be at risk of extinction. The decision to list steelhead will be made by NMFS in the future. Chinook stocks below the confluence of the Trinity and Klamath Rivers are under consideration for listing as threatened. Normally, robust populations can withstand environmental perturbations and recover over time, however, this is not case for the Klamath River for the reasons described below.

Loss of fish habitat, problems with chronic and acute water temperatures and excessive nutrients, commercial over harvest, and climatic changes have resulted in declining populations of steelhead, chinook and coho salmon. Poor timber management, placer mining, Klamath Project operations, water diversions in the Scott and Shasta River watersheds and the construction of hydroelectric dams appear to have caused significant reduction in spawning, rearing, and emigration habitat throughout the watershed.

Over the last 40 years, a large body of information has been assembled on the affects of water temperature on salmonid adult migration, spawning, egg incubation, alevin emergence, fry and juvenile rearing. Bartholow's (1995) literature review of salmonid temperature tolerances and study of Klamath River water temperatures support the premise that high summer temperatures $\geq 15°$ C from late June through early September have a detrimental affect on coho and chinook salmon and steelhead trout.

High temperatures are a function of climate and massive landscape changes throughout the Klamath River watershed. Temperatures recorded at Klamathon in the early 1900's (preproject) indicate the Klamath River was on average several degrees cooler than at present (M. Belchik, Yurok Tribe, per. comm.1998). Additionally, blockage by dams and degradation of tributary habitat have eliminated most or all of the thermal refugia areas in the upper portion of the Klamath River below IGD thus forcing greater reliance on mainstem habitat (M. Belchik, Yurok Tribe, per. comm.1998).

Fish kills occur in the lower river and Upper Klamath Lake due to poor water quality. For example, bacterial fish diseases such as *F. columnaris* thrive in high water temperatures typical of the summer months in the lower river. *Aerimonias hydrophylla*, another bacterial disease and anchorworm, a parasitic copepod, are also indicators of some of the stresses affecting the fisheries. High water temperatures and low dissolved oxygen combined with bacterial diseases and parasites were largely responsible for the 1997 and 2000 fish kills below IGD. Dead fish are observed annually around the second week in August in fish traps monitored by the Fish and Wildlife Service. These deaths are attributed to heavy algal loads and high water temperatures (T. Shaw, Fish and Wildlife Service, per. comm. 2000).

Water diversions from Klamath River basin tributaries have played a significant role in the decline of Klamath River salmonids. Historically, tributaries played a vital role in sustaining coho, steelhead, and chinook stocks in the Klamath Basin. Agricultural diversions in the tributaries have reduced flows to levels that abrogate fish passage for adults and rearing and emigration of juveniles. Subsequently, progeny may be stranded in tributaries in unfavorable conditions. All of these activities described above have in some manner altered water temperature, water quality, and the duration, frequency, and magnitude of Klamath River flows.

Agricultural practices in the Lost, Shasta, and Scott River watersheds may have released herbicides and pesticides into the Klamath River. However, no evidence exists indicating adverse affects of pesticides or herbicides on Klamath River resident or anadromous fish.

Upper Klamath Lake and the Klamath River are highly eutrophic systems from naturally and man-caused phosphorous and nitrogen compounds and pollution in the form of ammonia and nitrates. Waste water from Klamath sewage treatment plant, U.S. Timberlands, and South Suburban sewage; leachates from the Columbia Plywood log storage facility; return water from the Klamath Project area; and irrigation returns in the Scott and Shasta watersheds all contribute to the high nutrient load and biological oxygen demand in the Klamath River above and below IGD. High nutrient levels promote plant and algal growth, which cause diel fluctuations in the river’s dissolved oxygen level because of plant respiration. Water quality degradation cannot be discounted as one of the major factors leading to the decline of Klamath River steelhead, coho, and chinook.

Commercial ocean fisheries also have reduced salmonid stock abundance in the Klamath River system up to 70 percent (Rankel 1980 as cited by NRS 1997).

Logging activities and timber harvest dating back to the early 1930's have resulted in considerable degradation of fish habitat in the lower Klamath River watershed and play a role in the decline of Klamath River salmonids. Road construction created impassable barriers to steelhead and salmon spawning areas in Coon, Crawford, Little Girder, and Beaver Creeks (Taft and Shapovalov 1935 as cited in Vogel 1997). Logging caused aggradation in the lower reaches of Blue and Roach Creeks, blocking spawning access during low water (ESA 1980, Payne 1989 as cited in NRS 1997).

Generally, water supplies in the Upper Klamath Basin are insufficient to meet the competing interests for water supplies of the basin in every water year type. Water rights in a large portion of the Upper Klamath Basin are currently unadjudicated. The Upper Klamath Basin Working Group is working with private entities throughout the Upper Klamath Basin to prioritize watershed restoration projects and implement restoration using federal and private money. It is likely that additional reclaimed wetland areas will be restored and degraded riparian areas fenced. Reclamation is seeking additional sources of water and storage capacity to assist in meeting the many demands for water in the basin.

The timing of flow events is also critical because the life cycles of many aquatic and riparian species are timed to either avoid or exploit flows of variable magnitudes. Natural timing of high or low flow events provides environmental cues for fish to initiate spawning (Montgomery et al. 1983), egg hatching (Naesje et al. 1995), rearing (Seegrist and Gard 1972), and migration (Trepanier et al.

1996).

Although no Klamath River-specific data exists, a general positive flow versus survival relationship has been found in the majority of other geographic areas where this relationship has been studied (Cada et al. 1994). However, there are other studies that have demonstrated a positive relationship does not hold true uniformly for all ranges of flows (Vogel 1998).

It has been shown that high flows maintain ecosystem productivity and diversity. For example, high flows remove and transport fine sediments which otherwise would fill interstitial spaces in productive gravel habitats (Beschta and Jackson 1979). Other studies support the premise that higher flows would result in higher salmonid smolt survival because these fish would outmigrate faster and reduce exposure time to poor mainstem habitat conditions (Wagner 1974, Lundquist and Ericksson 1985, Glova and McInerney 1977, and Smith 1982 as cited in McCormick and Saunders 1987).

High mainstem spring flows may be necessary to provide rearing habitat for fry and juvenile coho and other salmonids outmigrating from the tributaries. Degraded fish habitat and poor water quality conditions in some tributaries, especially in low water years, may prematurely force the outmigration of salmonids into the mainstem Klamath River. Phase II results should provide additional information on flow needs of rearing salmonids.

Additional baseline studies are needed on fish distribution and relative abundance, location of crucial spawning and rearing areas in the mainstem and tributaries, and flow studies determining habitat conditions for all life stages of chinook, coho and steelhead under a range of flows and water year types. Further, data are not available to quantitatively determine the survival benefits for each species and life stage or the requirements to achieve long-term conservation and restoration of the Klamath River fisheries. Absent this information, it is virtually impossible to assess the cumulative impacts of a multi-year plan of operation.

8.0 DETERMINATION OF EFFECTS

Reclamation has determined that the proposed action for project operation may affect the continued existence of southern Oregon/northern California coho salmon. Further, Reclamation has determined the proposed action may adversely modify proposed critical habitat.

Flows in the Klamath River below IGD resulting from operation of the Klamath Project may affect rearing and outmigrating fry and juvenile coho salmon.

Depending on water year type, from June through September, a combination of high water temperature ($15° C), low dissolved oxygen, and flows as described in the proposed action with the Project could place rearing salmonids at risk. The extent to which Project operation affects water temperature and summer and fall mainstem river water levels is complex (Balance Hydrologics 1996).

The Klamath River has probably always been a relatively warm river. Insolation (solar radiation) and ambient air temperatures are primary factors affecting water temperatures in most rivers, including the Klamath. Both of these climatic factors are independent of Project operations, and increasingly govern water temperatures with greater distance from IGD (Balance Hydrologics 1996, Hanna 1997). Depressed salmonid populations and the successful introduction of many warm water fish species in the reservoir system suggests natural climatic conditions coupled with major landscape alterations in the Klamath River watershed and its tributaries have increased water temperatures, favoring fish species other than salmonids.

Additional research is needed to assess the impact of Klamath Project operations and other activities in the Klamath Basin on anadromous fish. Over the last 50 years, a considerable amount of information has been collected by federal, state, tribal, and corporate entities on Klamath River salmonids. Much of the information describes fish habitat and their populations in the Klamath River watershed dating back to the 1940's. Recent work by CCFWO, the Yurok Tribe of California and the Karuk Tribe are valuable in understanding the Klamath River fisheries and the overall mechanics of the watershed. Additional studies needed to gain a comprehensive understanding of the Klamath Basin aquatic ecosystem should focus on obtaining 1) information on spatial distribution and temporal abundance of fish (all life stages) within the mainstem river and it's tributaries, 2) the relationship of flow and the availability of spawning, incubation, rearing, and outmigration habitat, 3) the effects of water quality on egg to smolt survival, 4) reliable data on run strength in the mainstem using direct enumeration, 5) detailed information on pollution sources and relative contribution of each source to the nutrient loads in the Klamath River, and 6) diurnal temperature effects on fish.

Macrohabitat conditions, primarily elevated water temperature from late June through September, override the benefits of suitable microhabitat (depth, velocity and cover) for young-of-the-year and juvenile salmonids. Microhabitat appears to be most limiting in the spring (March, April, May, and early June) as it relates to river stage and the availability of mainstem Klamath River edge habitat. Project operations in the spring may minimize potential stranding impacts should benefit coho salmon.

Elevated water temperatures create a population bottleneck in late June through September as water temperature exceeds chronic (> 15° C) and acute (>20° C) thermal thresholds for YOY and juvenile salmonids. Bartholow (1995) reports acute thermal effects for salmonids, especially egg and larval life stages, were expected to occur at mean daily water temperatures of 20° C, or for consecutive exposures at a weekly mean temperature at 15° C.

Higher flows than the proposed action flows below IGD from July through September time period will not likely provide meaningful reduction of mean water temperature to levels below chronic and acute levels for salmonids. Deas and Orlob (1999) reported higher flows from IGD in August reduced water temperatures approximately 0.6° C, but not below the chronic or acute levels typical of summer conditions. The temperatures of water released from IGD and temperature records at Seiad from late June through early September approach or exceed acute thermal thresholds. The fish kill in 2000 occurred with a water temperature reaching a high of 24.03° C and a discharge of about 1,500 cfs in July. Releases at IGD were approximately 1,000 cfs. Although fish do survive these temperatures, the complexity of the relationship between river flows, water temperatures, and benefits to the fishery in the Klamath River warrants further investigation. Hardy Phase 2 results will hopefully provide additional information on this issue.

Care should be taken before applying the laboratory results for thermal preferences to wild fish because of the interactive effects of other factors including predation, inter- and intra-specific competition for microhabitat, availability of food for maintaining high metabolic rates, and instream hydraulics. All of these factors can influence the temperature selected by wild and hatchery fish (Myrick, 1998 cited from Moyle and Baltz , 1985)

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